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DYSTROPHIC MORPHOLOGY AND ITS SIGNIFICANCE[1]

AMONG the environmental factors which influence the structure and functions of the living organism, nutrition is of primary importance. One of the most fruitful methods of studying the process of nutrition is that of inanition. By withholding or decreasing the normal diet (total inanition) or merely one or more of the essential nutritional elements (partial inanition), we may observe effects which throw much light upon the normal process of nutrition from the standpoint of physiology, of pathology or of normal morphology. It is with the morphological aspect of the problem that we, as anatomists, are primarily concerned. We desire to learn the significance of the form and structure of the living organism and the factors concerned in its morphogenesis.

Experimental work by many investigators in this field during the past century has resulted in a large number of widely scattered data concerning the effects of inanition upon the growth and structure in numerous species. These effects of inanition have been extensively and carefully studied, not only in the vertebrates, but also among the lower organisms, the invertebrates and the plants. It may therefore be profitable to review briefly some of the principal results of inanition in these lower forms, partly because they are less well known to anatomists in general and partly because certain aspects of the problem are more clearly revealed in these simpler organisms. In general, only those phases will be considered which appear of most significance in comparison with the results in the higher animals, including man.

EFFECTS OF INANITION IN PLANTS

Plants in general, much more than animals, appear susceptible to modification by various

[1] Presidential address, American Association of Anatomists, Chicago, March 29, 1923.

external factors, including the food supply. It is difficult to summarize briefly the principal morphological effects of inanition upon plants on account of the wide range in the character of these organisms and the great differences in their mode of nutrition. In general, however, it is clear that the effect of inanition is to restrict or inhibit their growth during the developmental period, often resulting in premature development with the production of marked abnormalities of form and structure. In the poppy (*Papaver*) an inheritance of some of the experimentally produced variations is claimed (De Vries, Hoffman, Rignano). In later stages the plants are usually less susceptible; but sooner or later a deprivation of nutriment will usually produce protoplasmic atrophy and progressively degenerative changes in the cells and tissues, finally resulting in the death of the organism. Of the cell constituents, the formed storage products (starch, oil, etc.) are usually consumed first; then the cytoplasmic structures are attacked; lastly the nucleus, which is the most resistant.

These effects are produced not only by general or total inanition (either complete or incomplete) but also often in a strikingly characteristic manner by partial inanition, when there is a marked deficiency of only one (or a few) of the numerous essential factors of plant nutriment. Lack of any one of these factors—water, calcium, potassium, magnesium, iron, phosphorus, sulphur, manganese, nitrogen, carbohydrates and possibly vitamins—will cause stunting of growth with variable degenerative cell-changes. These are expressed by morphological and physiological derangements, often resulting ultimately in the death of the organism. The effects are apparently most severe in the case of phosphorus or nitrogen deficiency.

In addition to the deleterious effects more or less common to all these partial deficiencies, there are in each case certain peculiarities due to the special functions which each of the food-elements normally performs. These peculiarities appear also to vary considerably in different classes of plants.

Thus water deficiency is usually expressed promptly by characteristic changes in form and structure of plants on account of its fundamental importance in morphogenesis and vital structure, as well as in transportation. Of the various salts, those of calcium, potassium and magnesium are especially essential for chlorophyll production and starch formation. Phosphorus appears to be more concerned with the transformation than with the origin of carbohydrates. Cellulose formation proceeds in the absence of phosphorus, but is impossible without calcium. Mitosis may occur in the absence of calcium or of magnesium, but not without potassium or phosphorus. The process of inflorescence and the development of the sexual organs in general appear to be unusually susceptible to the effects of malnutrition and in some cases (especially in fern prothallia) a deficiency of calcium or nitrogen may influence sex by inhibiting the development of the female organs (archegonia).

EFFECTS OF INANITION IN PROTOZOA

Some of the more important results of inanition among the protozoa may be indicated briefly in relation to changes in body size, endoplasm and ectoplasm, nucleus (macronucleus and micronucleus), reproduction (cell-division and conjugation) and recovery upon refeeding.

Change in size and form of the body—All the evidence shows a marked reduction in the size of protozoa during inanition. The maintenance of the original size in *Noctiluca* is merely apparent, the increase in peripheral vacuoles masking the decrease in cytoplasm. The recorded data indicate a decrease in length to about one half of the original in *Paramecium*, one fifth in *Stentor* and one tenth in *Dileptus* and *Pleurotrichia*. Thus in these extreme cases the volume may be reduced to less than one per cent. of the original. The rapidity of the loss varies according to temperature. There are also more or less marked and variable changes in form accompanying the diminution in the size of the body.

Changes in the endoplasm—The cytoplasmic changes at first appear chiefly in the endoplasm, which becomes progressively reduced in amount and transparent, on account of the disappearance of the food-vacuoles and similar inclusions. In the later stages of inanition a progressive vacuolation of the endoplasm has been described in various species by all recent observers except Lipska. Such vacuolation of the

endoplasm apparently does not occur in *Noctiluca* and *Pleurotrichia*, however, and Lipska's results indicate that even in *Paramecium* it is probably only an indirect effect of inanition, being due primarily to other environmental factors.

Changes in the ectoplasm—In all cases the cell-membrane and associated ectoplasmic structures (cilia, trichocysts, cytopharynx, etc.) appear more resistant than the endoplasm, but in the later stages of inanition they also may be attacked and partially resorbed. Associated with these regressive changes there is a progressive decrease in motility and in other vital phenomena.

Nuclear changes—The nucleus in general is much more resistant than the cytoplasm, but may show changes in form with loss of chromatin content. In forms such as *Paramecium*, with macronucleus and micronucleus, the former shows more distinct changes. In the earlier stages of inanition it frequently elongates and enlarges. Later it usually divides and may show degenerative changes, with granulation, vacuolation, fragmentation and variable extent of resorption. The micronucleus usually persists practically unchanged, although rarely it may divide with reunion of the daughter nuclei. This persistence of the nucleus is a factor of great importance for the survival of the organism during periods of inanition. The less important constituents of the organism are usually consumed first, the most essential apparently survive longest. The persistence of the nucleus during starvation recalls a similar behavior when living cells are engulfed and digested (*e.g.* by *Trichosphaerium*, according to Schaudinn) and in trypsin digestion experiments upon dead cells. This may be of significance as indicating the presence of similar enzymes during the autolysis of cells in starvation.

Effects on reproduction—The relations of inanition to reproduction in protozoa have attracted much attention. Many observers have noted an apparent stimulus to division resulting from a brief period of starvation. R. Hertwig, however, observed that while under certain conditions fasting protozoa may divide more readily than well nourished, as claimed by Jickili and others, this does not occur as a general rule. In *Paramecium*, which has been more extensively studied, divisions occur to a variable degree in the early stages of inanition, but rarely or never in the later stages. According to Hertwig's theory, inanition upsets the cell-equilibrium as expressed by the nucleus-plasma ratio; but the relative increase in the nucleus may be equalized later by a reduction in chromatin, associated with the process of conjugation.

Rolph, who proposed a nutritive theory of sex, claimed that conjugation occurs in protozoa when conditions result in an interference with their nutrition. Thus sex is considered as primitively a form of hunger, which drives the organism to engulf its neighbor ("isophagy"). A similar theory of sex was elaborated by Geddes and Thompson. The studies of Maupas and of numerous more recent investigators, however, have shown that the life cycle of the protozoa, with its phases of sexual and asexual reproduction, is apparently a very complicated process, involving both internal and external factors. Among the latter, inanition is doubtless an important factor, which under certain conditions may induce conjugation. This was observed by Maupas and others in numerous species of Infusoria. Hertwig discovered that when low temperature cultures (which have a relatively large nucleus) are placed at a high temperature and kept without food, an artificial depression is produced which leads to conjugation. This was confirmed by Prandtl for *Didinium*, and by Popoff for *Epistylis*. Conjugation has been observed in the earlier stages of ordinary inanition in *Paramecium* by Kasanzeff, Wallengren and Chainsky; but Calkins and Lipska found inanition very unfavorable to conjugation. It is evident that further research is necessary in order to clear up this fundamental problem.

Recovery upon refeeding—The protozoa show an astonishing capacity for recuperation upon careful refeeding after inanition. Maupas found that an atrophic *Stentor* regained its original size in two days of abundant realimentation, which evidently involved an increase of over one hundred times its reduced volume. Joukowsky observed a similar remarkable capacity for recuperation in *Pleurotrichia*. In *Paramecium* Wallengren found a normal re-

covery possible, even in the greatly vacuolated condition after fifteen days of inanition. Lipska, however, found recovery in general possible only up to four or five days of inanition. The process of recovery is the inverse of that during inanition, and cell-divisions begin after three to five days of refeeding. Jennings noted that variability in size is increased during refeeding, some individuals recuperating more rapidly than others; but the normal condition is eventually restored.

EFFECTS OF INANITION AMONG THE HIGHER INVERTEBRATES

Although it is impossible to summarize satisfactorily the effects of inanition upon such a large and varied group of organisms as those represented by the metazoan invertebrates, it may be profitable to review briefly some of the principal features involved.

Effects on body weight and size—As pointed out by Pütter, the possible decrease in dimensions during inanition is much less in those forms having a firm skeleton (*e.g.*, Arthropoda). The maximum possible reduction in body weight and size varies greatly among the higher invertebrates, ranging from fifteen or twenty per cent. in some Arthropoda to over ninety per cent. in some coelenterates and planarians. Among coelenterates, *Hydra* is reduced to one seventh or less in length; the jellyfish *Aurelia* to one fourth and *Cassiopea* to one twenty-fifth of the original volume. Planarians (flatworms) may be reduced one twelfth in length and to one three hundredth in volume. In the snail *Helix*, the loss in weight apparently varies from eleven to fifty per cent. or more, according to species and conditions, with much individual variation. Among the Arthropods a loss of seventy-five per cent. in weight is recorded for the water-flea *Daphnia* and of fifteen per cent. for the crayfish *Astacus*. Great variation has also been found among the insects.

There are relatively few data on the loss during inanition in larval stages. The larvae of the sea-urchin *Strongylocentrotus lividus* may decrease to half the diameter of the original ovum. *Chortophaga* nymphs lose twenty to twenty-five per cent. and the tent-caterpillar (*Clisiacampa*) thirty-five per cent. The remarkable reduction (to one six hundredth) in the larva of the beetle *Trogoderma* is apparently exceptional. The loss during the pupal stage in general appears relatively slight.

Effects on the form of the body—During inanition the body is not only reduced in size, but also frequently more or less changed in form. *Hydra*, for example, becomes at first abnormally elongated, later greatly contracted and relatively broader. The water-flea *Daphnia* presents a peculiar modification of body form attributed to malnutrition and said to be hereditary (Woltereck). In the sponges, the coelenterates and the planarians the changes are remarkably great, not only in external form but also in corresponding internal structure. The so-called "reduction" process in these forms more or less resembles a reversal of the developmental process, which will be discussed later. In planarians the involution frequently involves the posterior portion of the body to a greater extent, resulting in a relative enlargement of the head region. This is also true of the nemertine worm *Lineus lacteus*, but not of *Lineus ruber*, which illustrates the differences which may occur between species.

Changes in various organs and tissues—It is a remarkable fact that the various organs and tissues of the invertebrate body differ greatly in their resistance to inanition. Some undergo changes very quickly, others only after longer periods, and still others show a remarkable resistance. There are also differences in the extent of atrophy, as well as the order of sequence.

In the medusa *Cassiopea* the loss is almost entirely at the expense of the gelatinous ground substance; while in sponges, on the contrary, this substance is increased in amount. The ectodermal structures are more resistant but they atrophy to a variable extent in different regions. In planarians the intestinal epithelium, eyes, pigment tissue and sexual duct systems are affected relatively early; the muscles atrophy later, while the gonads and nervous system persist with great tenacity. In *Lineus* the relative resistance of the various tissues is somewhat similar to that in planarians. Although among the higher invertebrates the skeleton is usually unaffected by starvation, in the snail *Helix* the calcareous shell is attacked as well as the soft tissues; while in

sponges the results appear variable. Calcium deficiency usually causes involution of the invertebrate calcareous skeleton, both in larval and adult stages. In the reproductive passages of *Helix* the non-glandular parts appear more resistant than the accessory albuminous gland, which undergoes an enormous involution. While the gland cells are greatly reduced, however, the associated "parenchyma" (stroma) nuclei persist and proliferate by amitosis.

Effects on the gonads and sex—The effects of inanition upon the reproductive system and process have aroused much interest and have been carefully observed in various invertebrates as well as in other organisms. In forms where the process of reproduction may be either asexual (by budding, fission or parthenogenesis) or sexual, the tendency of abundant nutrition is to favor asexual reproduction; while inanition or other unfavorable environment usually occasions a change to the sexual form, in many cases especially favoring the development of males. The gonads themselves are usually very resistant to starvation, being (like the nervous system) as a rule among the last of the organs to undergo involution. There are, however, evident variations in different species and individuals.

Among sponges the process of involution during inanition frequently results in the formation of numerous small bodies ('gemmules'), from which new individuals may be reproduced later. In *Hydra* budding is inhibited but the gonads, especially the testes, may mature in spite of the atrophy of the body as a whole. The predominating development of testes in *Hydra* during inanition was emphasized by Nussbaum, Schultz and Berninger, but was denied by Hertwig, Whitney, Hänel, Krapfenbauer and Frischholz.

In planarians asexual reproduction is inhibited by inanition and there is a return to sexual reproduction; but the 'cocoons' are reduced in size and the number of enclosed young markedly diminished. In the nemertine worm *Lineus* the gonads undergo partial involution, but some areas (likewise the ducts) are very persistent.

In the rotifers (wheel-animalcules) Leydig noted that inanition causes prompt atrophy of the ovary and a tendency to production of males. Nussbaum concluded that in the rotifer *Hydatina* underfeeding in the *phase preceding the ripening of the ovum* tends to produce male offspring. This was confirmed by Lennsen but opposed by Whitney. Shull concluded that sex in *Hydatina* is determined by both internal and external factors, but that the production of males during inanition is probably only an indirect effect.

The relation of nutrition to sex has also been studied extensively in the crustacean water-fleas by Leydig and others. The change from parthenogenetic to sexual mode of reproduction under unfavorable conditions (especially inanition) in this group was noted by Kerhervé, Cuenot and Issakowitsch. More recently, the internal factors have been emphasized, although it is admitted that the hereditary tendency may be influenced by external factors, such as malnutrition, especially during the labile period of the ovum. Green recently concluded that in *Simocephalus* the sex is probably predetermined in the ovary, but is also subject to environmental influence, though probably not through starvation.

Among the insects the relations of nutrition to sex have been noted especially in the aphids (plant-lice), the Lepidoptera and the Hymenoptera. The appearance of winged male forms in aphids as a result of underfeeding was noted by Kyber (1813), Leydig and others. The same phenomenon in the grape-louse *Phylloxera* was found by Keller and Behr. Thus apparently all observers admit the effect of unfavorable environment, especially underfeeding, in causing the cessation of parthenogenesis and the appearance of males and sexual reproduction among the aphids. The conditions in this group therefore form strong evidence supporting the theory of nutritional sex-determination.

In the Lepidoptera, Treat observed a preponderance of males as a result of underfeeding the larvae of certain butterflies. This was not confirmed by Poulton, although he admitted that a lesser resistance to inanition in the female larvae might result in a selective mortality with survival of a relatively larger number of males. This, of course, is not strictly a process of sex-determination, but rather of sex-survival. In the underfeeding experiments by Kellogg and Bell on the silkworm *Bombyx*

and by Guyénot and Loeb and Northrup on the fruit-fly *Drosophila*, no effect on the sex-ratio was observed.

Among the termites and Hymenoptera the sex is known to be determined by fertilization, the unfertilized eggs producing the males. The diet, however, determines the development of the female reproductive tract, which in the few larvæ well-fed (with "royal diet") becomes functionally developed, producing the "queens"; while in the less richly nourished larvæ the reproductive tract remains rudimentary, producing the "workers" of which there may be different kinds, depending upon the amount of food available. There is some evidence, however, indicating that in wasps (and possibly other Hymenoptera) the sex-ratio may be affected by nutrition, but this is somewhat uncertain.

Among the invertebrates in general we may therefore conclude from the available evidence that malnutrition tends to favor the sexual, rather than the asexual, mode of reproduction. Furthermore, especially in Hydra, rotifers, daphnids and aphids the sex-ratio is at least to some extent subject to environmental influence, inanition tending to produce a preponderance of males. Wilson concluded that nutrition is one factor which may determine sex. Schultze reached this conclusion for Hydra and Hydatina, but felt less certain regarding the daphnids and aphids. How this influence becomes effective, however, is still a matter of uncertainty. The whole question requires further investigation, especially in the light of the recent theory of sex-determination by the accessory chromosome.

Effects on cell structure—We have noted that the effect of inanition is to produce a variable decrease in the size of the body as a whole, which is found to involve a variable reduction in the various parts, organs and tissues. This, of course, depends ultimately upon the changes in the underlying units, the component cells of the organism. Some cells are destroyed and absorbed, others persist more or less changed. From his study of the histological changes in *Hydra* and planarians during the involution process of inanition, Schultz inclined to attribute the marked decrease in size of the body to a decrease in the number of cells, those persisting being practically unchanged in size. The preponderance of evidence is against this view, however. Especially in the adult organism, all the cells of the body during inanition tend to undergo more or less atrophy. The extent and character of this atrophy vary in the different tissues and in different cells of the same tissue. The decrease in the size of the body is therefore due partly to the complete disappearance of cells and partly to an atrophy of those persisting.

During the process of atrophy the cytoplasm of the starving cells undergoes in general a series of characteristic changes, first losing its stored food material, pigment, mitochondria and various inclusions. Later the cytoplasm of the cells often fuses into a syncytium. Vacuolation usually appears, with progressive decrease in amount of the cytoplasm, and terminal disintegration with complete absorption in the case of some of the cells. There is usually an earlier stage of reduction in size (simple atrophy) and a later stage of degeneration.

The nucleus is usually more resistant than the cytoplasm, giving a higher nucleus-plasma ratio. At first the nucleus may even enlarge, but later it tends to shrink (pycnosis) with perhaps ultimate fragmentation, karyolysis and final absorption. The reduction in cytoplasm and relative increase in nuclear size frequently gives the atrophic tissue an embryonal appearance.

Some further special features in the atrophic cell changes may be reviewed briefly. As noted by Terroine from the chemical viewpoint the fat changes show great variation among species and individuals. While fat in general is quickly absorbed during inanition, in the vitelline gland cells of planarians it is tenaciously retained, disappearing only when the cells undergo final necrosis. In planarians and molluscs the nerve cells may show certain degenerative changes, although the nervous tissue as a whole is remarkably resistant. It may be noted that apparently the final absorption of the degenerated cells in the various tissues is usually accomplished by simple solution in the interstitial tissue fluids; although phagocytosis has been noted in sponges, sea-urchin larvae and especially in the case of the nemer-

tine worm *Lineus*. The process of phagocytosis is said to occur also in the metamorphosis of insects.

Some specific changes in cell-structure are noted during various forms of partial inanition. Thus calcium deficiency may loosen the intercellular attachments but it does not affect the ciliary mechanism and apparently permits mitosis to continue in the embryonic tissues of various invertebrates. Phosphorus and potassium, however, are evidently necessary for mitosis, as in plants. In addition to the mineral salts, certain proteins, fats or carbohydrates, water, etc., are doubtless essential to life, but we have as yet little data upon the morphological effects of their deficiencies among the higher invertebrates.

Effects on the developing organism—The effects of inanition upon the developing invertebrate organism, especially during the earlier embryonal stages in many respects often differ markedly from those previously described for the adult. The embryonal cells have a characteristic tendency to growth and differentiation which may enable certain organs and tissues not only to persist but even to enlarge and develop at the expense of the remainder of the starving organism. This is true for general inanition and is also especially evident during various forms of partial inanition. Thus in many cases it is evident that a deficiency in one limiting factor does not necessarily altogether inhibit the development of the invertebrate organism when that factor is exhausted, but occasions instead a disproportionate, abnormal growth, the extent and character of which will vary according to circumstances.

On the other hand, in many cases the developing embryo or larva (in some species even the adult organism) tends to undergo during inanition a series of retrogressive changes more or less reversing the normal order of development. This process (technically called 'reduction') was apparently first described by Lillie (1900) in *Planaria maculata*. It is often well marked in sponges, coelenterates and planarians, though apparently rare in the more highly organized invertebrates. Even in the lower invertebrates, however, there is some question as to whether the (often remarkable) resemblance of the atrophic organism to the earlier embryonic stages may not be more apparent than real. But in many cases these atrophic remnants are actually able, under proper conditions of nutrition, to regenerate the normal structure of the organism. Child concludes that starvation results in morphological rejuvenation, followed by physiological regeneration upon refeeding.

The relatively great resistance to inanition usually offered by the gonads has already been mentioned for adults. This applies also in some cases to the developing organism, so that sexual maturity may occur in undersized bodies as a result of underfeeding (*e.g.*, silkworm and certain bees). But in others (starfish) sexual maturity is reached only upon the attainment of a certain body size, or the development of the gonads may even be entirely inhibited by inanition (fruitfly).

The sex of the offspring, as already mentioned, may also be influenced through the effect of inanition upon the germ cells in the larval stages, particularly at certain critical periods (rotifers, daphnids, aphids, etc.). In some insects sexual maturity appears to be determined entirely by larval nutrition, in others chiefly by the adult nutrition.

Underfeeding during the larval period may also result in undersized adults (various insects) and also sometimes in marked structural modifications (pigmentation, etc.). In some cases these acquired characters appear hereditary, at least for a few generations (as found by Woltereck, Pictet, Kellogg and Bell); although ultimately upon adequate diet there is an evident tendency to return to the original condition.

The experiments with media or diets variously deficient have shown that compounds of P, K, Na, Ca, Mg, Fe, S and Cl appear necessary for development, growth being inhibited or variously perverted when the amount stored in the ovum is exhausted, unless a supply from without is available. Remarkable results in this field have been obtained by Herbst, Loeb and others. The marvelous effect of fat upon the development of the reproductive tract in the female Hymenoptera also illustrates the morphogenetic potency of a single dietary factor. As to other forms of partial inanition, Baumberger holds that protein is

in general the limiting factor in the growth of insects. The fruitfly *Drosophila* apparently requires yeast as well as sugar for growth and other insects living on fermenting substrata of low protein content usually feed on the micro-organisms present. Little or nothing is known concerning the possible requirement of vitamins by the invertebrates in general.

Regeneration during inanition—In many of the invertebrates indications of regenerative activity may be observed in certain cells or regions during the degenerative process of involution. Driesch noted that the reserve materials of the body which are consumed during starvation may be used to build up other parts of the organism. Thus in daphnids, crustacea and insects repeated ecdysis (moulting) with regeneration of a new exoskeleton and appendages may occur during total inanition. This regenerative process occurs notably in the lower invertebrates such as the sponges and coelenterates and has been studied especially in planarians by Morgan, Schultz and others. Here the starving organism exhibits the remarkable capacity to regenerate large portions of the body, such as the head, with all its parts, pharynx, nerve ganglia, musculature and excretory system. Thus even during starvation regeneration may restore a complete normal individual of much smaller size. In this process there is an extensive involution of the older tissues to furnish material for the regenerated parts.

Recovery upon refeeding—In general it is possible for the starving invertebrates to recover their normal size and structure upon appropriate refeeding if the process of involution has not proceeded too far in degeneration. This applies also to partial inanition. In sponges, for example, the skeleton is reformed upon restoring calcium carbonate to the medium. In planarians regeneration of the gonads is possible even when they have nearly disappeared after three or four months of inanition. In the gland cells of the snail *Helix* starved five months, evidences of recuperation were found by Krahelska even after only two days of refeeding. *Drosophila* (fruitfly) larvae are capable of normal development even after long periods of retardation on inadequate diet; and in this form, as likewise in the larvae of the beetles *Trogoderma* and *Tribolim*, the normal period of life may be greatly extended by retarding the developmental process through alternate periods of fasting and refeeding. Underfed larvae of the moths *Acronyeta* and *Bombyx* produce smaller pupae and adults, the effect in the case of *Bombyx* being carried over to the second and third generations.

COMPARISON WITH VERTEBRATES

Comparison of the results of inanition among plants and invertebrates with those found in vertebrates reveals many differences. Especially in the degree of change the vertebrates appear in general less plastic and more resistant to inanition, as to environmental influences in general. Thus while many invertebrates may survive a loss of ninety per cent. or more in weight, vertebrates usually perish when the loss reaches forty per cent. Likewise there are found among vertebrates no such radical and profound changes of structure as may occur during inanition among plants and many invertebrates, especially in those which undergo the remarkable process of "reduction."

On the other hand, amidst the diversity of phenomena resulting from inanition in the various plants and invertebrates we find certain features in essential agreement with those occurring among vertebrates, indicating a fundamental resemblance in the reactions of all living organisms. This applies not only to the general atrophy of the whole body, but also to the variable extent and character of change in different parts and organs. Thus the nervous system and (usually) the skeleton are relatively resistant to inanition in both vertebrates and invertebrates. The variable losses in the different parts of the body lead to marked abnormalities of form which differ greatly according to circumstances.

During the development in both animals and plants, inanition (especially of the chronic type) frequently results not merely in a retardation or cessation of growth, but in an abnormal, disproportionate growth, which differs greatly according to the species, stage of development, type of inanition and other factors. Some parts may show persistent growth at the expense of others, even during total inanition

with continued loss in body weight. This applies likewise to various types of partial inanition. The abnormal growth occurring in the absence of certain dietary elements necessary for normal nutrition is contrary to Liebig's "law of the minimum or limiting factor" according to which (as narrowly interpreted by some authors) growth should cease when any factor essential for normal growth is exhausted. Whatever may be the influence correlating the relative growth of the various organs and parts this correlation may be markedly changed during total or partial inanition and the process of morphogenesis is accordingly subject to experimental control.

The possibility of regeneration and recuperation upon refeeding after inanition, although more strikingly evident in the lower forms, is characteristic of all living organisms. Although the effects of inanition vary widely in different cases, up to a certain stage of severity perfect recovery is possible; beyond this only partial recovery (or none at all) is possible, resulting in permanently dwarfed and stunted forms. The age at the time of inanition is very important, there being critical periods at which the various organs are most susceptible to change through inanition and other environmental factors. This is strikingly illustrated in the case of the effects upon the sex glands and possibly sex determination.

These various changes observed in the dystrophic organism are associated with changes in the constituent cells. The relative loss in cytoplasm and the resistance of the nucleus during inanition are characteristic in all plants and animals. The general result is to reduce the cell to a more embryonal type of structure with a modified nucleus-plasma ratio, which may perhaps in part explain many of the curious resultant changes in form during dystrophic growth. While mitosis is usually inhibited during inanition, it may persist with great tenacity in those organs in which growth continues.

While the cells during inanition are reduced to an embryonal condition, from which recovery is possible upon refeeding, they do not so remain permanently. Sooner or later, in all living organisms, they pass from a stage of simple atrophy to a condition of degeneration. The cytoplasm typically undergoes cloudy swelling, with subsequent fatty or vacuolar degeneration. The nucleus, though relatively more resistant, also later undergoes progressive degeneration, usually with pycnosis and finally karyorrhexis or karyolysis. It is apparent that the above mentioned possibilities of recovery depend chiefly upon the degree of cell injury which has been sustained. Cells which have undergone extensive cytoplasmic and especially nuclear degeneration are obviously unable to recuperate. There are always great individual differences, however, even among cells of the same organ, so that some may remain capable of regeneration even though others have degenerated beyond the stage of possible recovery.

The question as to why certain cells or organs have a greater resistance to inanition has received various answers. Roux has long held that during inanition those cells persist which require less food in the struggle for existence. This theory was opposed by Schultz and others who claimed that the order of disappearance of the (invertebrate) organs reverses the order of their appearance during ontogenetic and phylogenetic development. Another view widely held is the teleologic explanation that those organs persist longest which are most valuable to the organism or species. All such theories, however, appear inadequate to explain the facts observed. Runnström (for sea-urchin larvae) proposed a more rational theory, explaining the morphological changes upon the basis of the varying physico-chemical conditions in the starving organism. Future investigation along this line will probably give better comprehension of the phenomena involved.

The question may also be raised as to why the degenerative changes in the various cells during inanition are so similar, not only in the various types of total and partial inanition, but likewise in many other abnormal conditions, such as extremes of temperature, fatigue, toxic or electrical stimuli, etc. Various answers to this question are possible, but the most probable would appear to be that the effects are similar because these all represent conditions which obstruct the normal cell metabolism, thereby causing the same degenerative cell changes. The fundamental similarity in the cellular results of such varied conditions recalls the dictum of Cuénot that "la plupart des

influences de milieu se ramènent en somme à des différences de nutrition."

Nutrition therefore becomes a factor of primary importance for morphology as well as for physiology. The form and structure of all living organisms are clearly dependent in large measure upon the quantity and quality of their nutriment. The effects of inanition of various types apparently account for many of the variations observed among living organisms, under both normal and abnormal conditions. A knowledge of these effects gives a deeper insight into the process of morphogenesis and a means whereby it may be experimentally controlled to a degree hitherto generally unrealized. Furthermore, even though it be contrary to the generally accepted biological doctrine, there is another possibility which must be considered. Not only the somatoplasm, but under certain circumstances even the germ plasm may perhaps likewise be modified by nutritional conditions, a possibility of fundamental significance for heredity and evolution.

CLARENCE M. JACKSON

A RESEARCH CAREER IN ASTRONOMY

WIDELY different types of investigation are now included in astronomy, and only the most general remarks would apply to all of them. For the student who is considering a professional career in astronomical research it may be useful to outline the various branches from the standpoint of the personal aptitudes of the investigator.

THEORETICAL ASTRONOMY

For the mathematically inclined there is the great field of theoretical astronomy. The theoretical astronomer is a mathematician who uses the principles of mechanics, for example, together with calculus, infinite series, etc., to achieve his purposes, as a carpenter uses hammer and nails. If the tools and materials are not properly handled the structure either never rises at all, or collapses the first time its strength is tested. Hence a thorough apprenticeship is essential. Typical problems with which the theoretical astronomer deals are the computation of orbits of comets, planets, satellites, meteors and double stars; the more general problems of celestial mechanics, such as the formation of stars and stellar systems, or the stability of rotating bodies; statistical inquiries concerning the structure of the universe; and, of growing importance, the application of theoretical physics and chemistry to celestial bodies.

The theoretical astronomer can get along without a telescope, but he needs a library and the assistance of computers. His usual position, therefore, is that of professor of astronomy at a college or university. He will ordinarily be expected to conduct classes, but at many institutions some research will be possible if he is sufficiently eager and persistent. The American student who is looking forward to work of this character should prepare to teach, as there are few theoretical astronomers in the United States who do not have duties of instruction.

OBSERVATIONAL ASTRONOMY

Astrophysics—For one whose interest is along the lines of physics and chemistry there is the expanding realm of astrophysics. This science is concerned with deriving all possible information from a study of the quality and intensity of the light received from the heavenly bodies. The observational goal of astrophysics is a complete knowledge of the spectral energy curves (including state of polarization) of the light radiated from every celestial source. The heart of the matter lies in the interpretation of these curves and here astronomy and physics blend. The three main divisions are spectroscopy, photometry, and radiometry.

Spectroscopy is the study of spectral details, *i.e.*, lines and bands, without special reference to the absolute intensities. This line of work has undergone a remarkably extensive development since the pioneer days of Secchi and Huggins. The chief subjects of research are chemical identifications, physical conditions, radial velocities, and intrinsic stellar luminosities (which when combined with apparent luminosities give distances). There are, of course, many special problems of great importance, in particular, those referring to the disk of the sun. It would take too much space even to outline the contents and value of the branches of astronomical spectroscopy, but nearly every school library contains a few books describing them. Miss Clerke's "Problems in astrophysics" and "The

system of the stars," Hale's "Stellar evolution" and Campbell's "Stellar motions" may be mentioned.

Photometry has to do with the brightness and color of the stars, and is of value not only for the vast number of separate facts which have been gathered and which serve as essential aids to many investigations, but also for the general conclusions which may be drawn from its data. The science of star colors still remains in a rather crude form, however, and it is only a matter of time until the present methods will be largely superseded—at least for the brighter stars—by more complete and detailed methods of spectro-photometry. A most promising problem is the practical development and application of such methods.

Stellar radiometry, or the measurement of the radiation of the stars by the thermocouple or bolometer is in its infancy and has thus far consisted chiefly in observing the total, undispersed radiation. A few successful attempts have already been made, however, to adapt these instruments to stellar spectro-photometry, and it is certain that there is a fine future for this line of work.

The new science of stellar interferometry occupies an intermediate position between astrophysics and the astronomy of the measurement of position. Students who have a thorough acquaintance with the principles of optics and with laboratory interferometry are needed to develop this attractive field.

Astronomy, as a part of general physics, is capable of making important contributions to our knowledge of the properties of matter, of light and ether, and perhaps of the "nature of space." This prospect should attract the student whose ambitions are such as to lead him to devote himself to the type of work underlying the progress of science, even though his investigations may not find practical application in a month or a decade. There is a romantic appeal in the idea of studying the structure of the atom by observing objects invisible to the naked eye and so distant that light, which could encircle the earth seven times in a second, is hundreds of years in making the journey which ends on a human retina or on a photographic plate at the end of a telescope. With the aid of the mysterious but powerful "quantum" theory, knowledge of atoms and electrons and their relationships to light waves is progressing by leaps and bounds, and spectroscopic facts of all kinds are assuming an importance which was but dimly foreseen a few years ago. Properties of matter not yet exhibited in the laboratory can be studied in the stars by means of the spectroscope, but only a beginning has been made. It is doubtful whether space has any properties except those which are postulated into it, but perhaps the best way to talk about certain geometrical and physical relationships is to assume that space does possess objective properties. Our ideas of the relationship between space and ether are, at the present time, in an unsatisfactory state of profound confusion, the saving feature of which is that the foundations of physics are being scrutinized as never before. Much careful thought is required concerning these matters, and the investigator should be an astronomer, a physicist, and a mathematician combined in one.

Direct visual observation—To one who has keen eyesight and a fondness for making precise observations astronomy has much to offer. Double stars are discovered and measured visually. The determination of time and of the fundamental positions of reference stars depend on visual observations with meridian circles. Observation of the surface details of the moon and planets makes a strong appeal to some persons.

Photography—The taking of direct photographs of celestial objects, especially of comets and nebulae, is a never ending source of delight. Much interesting and profitable work of this kind can be done with telescopes having apertures from one to one hundred inches. Photography also serves for accurate position observations as in parallax and proper motion work and in star charting, and in recording solar and stellar spectra. In fact, photography is extensively used in so many types of work that the prospective observational astronomer should cultivate a thorough acquaintance with photographic operations and materials.

Nearly every type of work mentioned in this article, except stellar radiometry, can be successfully carried on with telescopes of moderate size, although in many instances the in-

creased power of large telescopes is a great advantage. Worth-while investigations and fine work of a miscellaneous character can be done with apertures of twelve inches and less. The small and medium-sized telescopes in the United States are capable of being used for research to a far greater extent than is the case at present.

Observational astronomy is carried on at special research observatories and by departments of astronomy in academic institutions. Excellent graduate instruction in astronomy may be obtained in any one of ten or twelve colleges in the United States. The two largest research observatories in which there are regular arrangements for the admission of students are the Lick Observatory at Mount Hamilton, California, and the Yerkes Observatory at Williams Bay, Wisconsin. In several places there are graduate fellowships or assistantships which pay the living expenses of the holder while he is working for a doctor's degree.

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As a basis for a worth-while research career in astronomy, the student should have an insatiable curiosity concerning the secrets of the stars, and unbounded enthusiasm for personal investigation. Without these he would surely find an astronomical career unenjoyable, and it would probably prove unprofitable as well; but possessing these qualifications and fortified by sound technical preparation, astronomy may be the only life work which he could carry through without vain longings and regrets arising from a sense of stifled aspiration.

PAUL W. MERRILL
MOUNT WILSON OBSERVATORY

SCIENTIFIC EVENTS

EPIDEMIC DISEASE IN EUROPE

THE sixth number of the *Epidemiological Intelligence Bulletin* has just been issued by the health section of the League of Nations Secretariat. According to the summary in the London *Times*, it deals with epidemic diseases in Eastern and Central Europe from May to December, 1922, and treats in some detail typhus and relapsing fever, Asiatic cholera, dysentery, smallpox, plague, epidemic diseases of the central nervous system, malaria and enteric fever. The statements are based on the number of cases notified. Actual comparisons between countries are generally impossible. Briefly summarized, the comparison between 1921 and 1922, in so far as the reports have been received, is as follows:

The incidence of typhus and relapsing fever was fully twice as great in 1922 as in 1921 in Russia, another extremely high epidemic wave having occurred in 1921-22. This wave was quite double the 1920-21 wave, but was less than half as great as the second wave of 1919-20, judging from the number of cases reported. In Poland no improvement in 1922 over 1921 was noted for typhus and the prevalence of relapsing fever has greatly increased. In Latvia there was apparently an increase of typhus, but a decrease of relapsing fever.

With the exception of the Ukraine and the Russian Black Sea littoral, the cholera situation improved considerably in 1922. In Russia, exclusive of the Ukraine, the number of cases reported in 1922 was about one fourth of those reported for 1921 since the great epidemic in South Russia of 1921 had come to an end. In the Ukraine, however, a serious epidemic occurred in 1922; the number of cases in July (the highest month), 1922, was four times as large as in July, 1921. No serious epidemics were noted elsewhere.

Notifications of dysentery probably mean nothing more than certain intestinal infections with similar clinical symptoms, but the prevalence of the disease in 1922 was apparently considerably less than in 1921 in all the countries concerned. Even in Russia, for which the reports are extremely incomplete, there is no evidence of unusual prevalence.

Smallpox declined in 1922 in all countries where it was markedly prevalent during the preceding year, although its incidence was still high in Russia.

Malaria assumed more alarming proportions in Russia during 1922 and the situation was rendered even more serious by the appearance of the tropical type in Eastern Russia. The million and more cases actually reported for Russia represent a small proportion of the cases which must have actually occurred.

The incidence of enteric fever was less during 1922 than during the preceding year in nearly all European countries.

FELLOWSHIPS OF THE ROCKEFELLER FOUNDATION

DR. ALONZO E. TAYLOR, of Leland Stanford University, has recently returned from Europe where, in the capacity of financial and economic expert, he was assisting Dr. R. M. Pearce in his survey of conditions in medical education. In the following paragraphs we are giving a brief outline of his description of the situation in medical science in Germany and of the results which may be expected from the aid which has been voted by the Rockefeller Foundation for German medical scientific men.

Just after the war, according to Dr. Taylor, the number of students entering medical schools in Germany was unduly large; now, however, it has diminished to about one fourth of the pre-war number. There are still plenty of young men desirous of doing research and special work, but facilities for such work are regrettably lacking. Buildings and basic equipment, it is true, are still effective, but current supplies—animals, instruments, chemicals and so forth—are prohibitive in price. The continuity of German science is, therefore, threatened in its quality and not for lack of men desirous of devoting themselves to the work.

The gift of the foundation for scholarships and fellowships in Germany Dr. Taylor considers the most important constructive assistance given Germany since the war. It will, he believes, have the double effect of aiding medicine and strengthening the influence of liberalism throughout the country. According to present plans it is probable that one hundred fellowships will be in active force by the first of February and one hundred more will be granted during the course of the next six months.

A total of 226 fellowships were granted during 1922 by the foundation and its various boards. Of these, seventy-nine were fellowships in public health administered by the International Health Board, twenty-two were under the Division of Medical Education, sixty-three under the China Medical Board and sixty-two were fellowships in physics, chemistry or medicine, supervised by a committee of the National Research Council. These fellows represent the following countries: Austria, 3; Australia, 3; Brazil, 20; Canada, 12; Ceylon, 1; China, 14; Costa Rica, 1; Colombia, 2; Czechoslovakia, 16; Great Britain, 9; Hungary, 3; Japan, 2; Jugoslavia, 2; Mauritius, 1; Mexico, 1; Nicaragua, 3; Norway, 1; Philippine Islands, 4; Poland, 10; Salvador, 1; Siam, 2; Syria, 3; United States, 111.

CHEMISTRY-COMMERCE COURSE AT THE UNIVERSITY OF WISCONSIN

THE growing importance of chemistry in modern commerce has brought about a condition which makes desirable the offering of a four-year university course in which the student may get the essentials of a commercial training, together with an amount of chemical training sufficient to enable him to understand the basic technical features of the industries with which he will come in contact.

The University of Wisconsin, realizing the necessity for such training, has established a new four-year course to be known as the chemistry-commerce course and which will be open to prospective students at the beginning of the school year 1923-24, in September. This course is intended particularly for men who desire to fit themselves to hold commercial positions such as business managers, technical secretaries, managerial secretaries, purchasing agents, technical salesmen and, in fact, any commercial position in which a thorough understanding of fundamental chemical principles would be an asset.

Men of affairs in the industrial world are often seriously handicapped because they do not possess a fundamental knowledge of the technical principles involved in their business. Each year it becomes more and more important for the business man to have a knowledge of the chemistry of the processes with which he is concerned. As our civilization advances and becomes increasingly complex, the successful application of sound chemical principles becomes increasingly important. While it is true that the business man may hire chemists or chemical engineers to develop the technical details of his business, it is equally true that he will be greatly handicapped unless he himself knows enough chemistry to be able to talk intelligently with these men. Without a fundamental knowledge of chemistry, their reports will mean but little to him and there will not be the sympathetic understanding which should

exist beween the executive office and the technical department. We are now living in a chemical age and the business man who has neglected to acquire a knowledge of fundamental chemical principles is in the same boat with the farmer who continues to use the methods of fifty years ago.

In addition to certain required courses in chemistry, economics, mathematics, foreign languages and English, a considerable number of free electives have been provided, so that the student may broaden his education in the direction he sees fit.

The course in commercial chemistry which runs throughout the junior year is not a course dealing with the engineering features in industrial chemistry. The students taking this four year course are interested primarily in the economic or commercial aspect of the subject, rather than the purely technical. Only so much of the technical will be given as is necessary for a background. It is the intention to give the student a wide acquaintance with commercial processes and materials of commerce, rather than a detailed, technical knowledge of a few. For those who desire a more technical treatment, courses in industrial chemistry will be open for election. In discussing processes and products, the emphasis will be placed on the chemistry and the economic conditions which determine the value of the process. Such subjects as the location of a plant with respect to all the factors involved will be especially emphasized. The cost of transportation of both raw and finished products will be studied. Each student will make a special detailed study of one typical plant and will turn in a report of his findings. Market reports will be analyzed and those factors which influence the fluctuation in chemical markets will be taken into consideration. The course may properly be called a "Survey of the field of commercial chemistry" and will interpret the rôle played by chemistry in commerce.

J. H. MATHEWS
Director

STANDARDIZATION OF TRAFFIC SIGNAL COLORS

FORTY-TWO men, representing the manufacturers and users of traffic signals, federal and state governmental departments, associations interested in the prevention of traffic accidents and representatives of the general public, are now at work on the drafting of a national code on the proper colors for traffic signals, which it is expected will not only cut down the annual loss of life through traffic accidents, but will eliminate many of the existing irritations to motorists and to the operators of steam and electric railways.

This work is being carried on under the auspices of the American Engineering Standards Committee, whose approval of a code or standard insures its ultimate acceptance and observance throughout the country. The American Engineering Standards Committee is composed of seven departments of the United States Government, the principal technical, industrial and engineering societies and individual business concerns interested in standardization.

The sectional committee drafting this code is made up of seven representatives of the manufacturers of traffic signals, nine representatives of the purchasers of such equipment, three representatives of the users of traffic signals, twelve representatives of governmental bodies, five technical specialists and six insurance representatives.

Charles J. Bennett, state highway commissioner of Connecticut, who represents the American Association of State Highway Officials, has been selected chairman of the sectional committee. M. G. Lloyd, of the United States Bureau of Standards, who is the representative of both the bureau and the American Society of Safety Engineers, is vice-chairman, and Walter S. Paine, research engineer of the Aetna Life Insurance Company, who is the representative of the National Safety Council, is secretary of the sectional committee.

THE LIBRARY OF WILLIAM JAMES

MORE than a thousand books from the private library of William James, who taught psychology and philosophy at Harvard University from 1872 to 1907, a large number of which contain marginal notations by him, have been presented to the university by his family. The collection is considered by Harvard library officials to be of unique interest and value to future students of the philosophical thought

of William James and the group of philosophers about him.

An important part of the collection consists of about 400 volumes, almost all of which have to do with philosophy, psychology and the moral sciences; these books have been selected, with the counsel and assistance of Professor Ralph Barton Perry and Dr. Benjamin Rand, of the philosophical department at Harvard, because of the unusual interest attaching to the annotations by Professor James which appear in them. They contain numerous marginal comments and interlineations, mostly in pencil, which throw light on the development of James' philosophical ideas and on the influences which shaped his thought.

There is another group of about 600 volumes, some of which have to do with psychical research, spiritism and abnormal psychology and some with the religious emotions, religious biography and topics touched on in James' "Varieties of religious experience." This second group is interesting as a collection because many of the books are not easily obtainable or are not ordinarily classified in library catalogs under the subjects to which Professor James related them.

Still another group consists of about fifty philosophical and religious books used by Professor James and containing annotations by his father, the Reverend Henry James. These books would be of special interest to students of the sources and influences of James' work.

Finally there are about twenty books, somewhat annotated, which the philosopher placed together shortly before his death with the intention of working up the subject of military psychology.

The collection as a whole is being transferred to the Harvard University Library, where arrangements will be made to place the books of the first group in the "Treasure Collection," where they will be accessible only to those qualified to consider and respect the marginal notations.

THE SWARTHMORE CHAPTER OF SIGMA XI

ON the afternoon of April 27, there was installed at Swarthmore College a new chapter of the society of Sigma Xi, to be known as the Swarthmore College Chapter. The ceremonies of installation were in charge of President Henry B. Ward, of the National Society, assisted by the national secretary, Edward Ellery. Delegates were present from the chapters at the University of Pennsylvania and at Rutgers College. The new chapter was initiated with twelve charter members, seven of whom were already members of the society. Unusual interest attaches to the establishment of the Swarthmore Chapter in that it has been a distinct departure from the previous policy of the organization that a charter has been granted to a group in an undergraduate institution. The chapter begins its activities under the following officers: *President,* John A. Miller; *vice-president,* Spencer Trotter; *secretary,* Winthrop R. Wright, and *treasurer,* Errol W. Doebler.

After the installation the national officers, the delegates, the chapter and the faculty and managers of the college were the guests of President and Mrs. Aydelotte at a reception held in their home. Following this reception a public address was given by President Ward in Collection Hall. Dr. Ward prefaced his address with a brief statement of the ideals and the achievements of Sigma Xi in encouraging and producing research and of the uniqueness of its position among the so-called honor societies. His address was entitled "On the trail of the Alaska salmon" and was illustrated with photographs secured by him during an investigation in the interest of the conservation of food supply.

The ceremonies were concluded with a dinner in the evening which was attended by about one hundred members and guests. The toastmaster, Ex-governor William C. Sproul, was introduced by President Aydelotte, who took this occasion to welcome the new chapter on behalf of the administration and to pledge the support of the college for the ideals of Sigma Xi. The principal address was made by Dr. A. L. Day, director of the Geophysical Laboratory, on "The approaches to research." Brief remarks were also made by Dr. C. E. McClung, past-president of Sigma Xi, Secretary Ellery, Ex-provost Edgar F. Smith of Pennsylvania and President Miller. The festivities of the evening were closed by President Ward, who wished God-speed to this, the youngest and smallest of Sigma Xi's chapters.

SCIENTIFIC NOTES AND NEWS

DR. GEORGE K. BURGESS has been appointed director of the Bureau of Standards to succeed Dr. S. W. Stratton, who resigned to become president of the Massachusetts Institute of Technology. Dr. Burgess has been connected with the Bureau of Standards for twenty years, becoming chief of the division of metallurgy in 1913.

AT a meeting of the executive board of the National Research Council held in Washington on April 24, officers were elected as follows: Chairman of the executive board, Gano Dunn; first vice-chairman, president of the National Academy of Sciences (A. A. Michelson); second vice-chairman, Charles D. Walcott; third vice-chairman, Robert A. Millikan; fourth vice-chairman, John C. Merriam; members at large of the executive board are H. E. Howe, Raymond Pearl, M. I. Pupin and William H. Welch. Dr. Vernon Kellogg is the permanent secretary of the council.

THE gold medal of the National Institute of Social Sciences was conferred on Dr. Charles B. Davenport on the occasion of the ninth annual dinner on April 25.

THE University of Edinburgh will confer the honorary degree of doctor of laws on Sir Charles A. Parsons and Mrs. Henry Sidgwick.

DR. H. H. DALE, head of the department of bio-chemistry and pharmacology of the Medical Research Council, has been elected a member of the Athenæum Club of London for eminence in science.

THE Jacksonian Prize of the Royal College of Surgeons of England for the year 1922 on "The effects produced by radium upon living tissues, with special reference to its use in the treatment of malignant diseases," has been awarded to H. Sidney Forsdike, of the Soho Hospital for Women.

WE learn from *Nature* that the British Institution of Mining and Metallurgy has made the following awards: The gold medal of the institution to Mr. Edgar Taylor, president, 1909-1911 and 1916-1918, in recognition of his services to the institution since its foundation in 1892 and as an evidence of appreciation of his honorable record of work in connection with the development of the mining industry, particularly in India; "The Consolidated Gold Fields of South Africa, Ltd." gold medal to Dr. Leonard Hill, in recognition of his valuable researches on ventilation and for his paper on "Ventilation and human efficiency," contributed to the *Transactions;* and "The Consolidated Gold Fields of South Africa, Ltd." premium of forty guineas to Mr. H. F. Collins, for his paper on "The igneous rocks of the Province of Huelva and the genesis of the pyritic ore-bodies," contributed to the *Transactions,* and in recognition of his researches on the subject.

THE Carthage biennial prize, founded in 1921, has been awarded for the first time to Dr. Nicolle, for his researches on the transmission of typhus and on trachoma, Malta fever, leishmaniasis and other tropical diseases.

PROFESSOR THEODORE J. STOMPS, of the University of Amsterdam, writes that a *bas relief* of Professor Hugo de Vries has been made by one of the best artists and may be had for $20. It is of plaster and natural size. A bronze medal 7 c.m. in diameter may be obtained at the same price. Orders may be sent to Professor Stomps.

A. W. AMBROSE, assistant director of the Bureau of Mines, resigned recently to become associated in an executive capacity with the Empire Companies, with headquarters at Bartlesville, Okla.

DR. CARL D. LA RUE, instructor in botany in the University of Michigan, has accepted an appointment for a period of one year as specialist in rubber investigations in the Bureau of Plant Industry, Washington, D. C. Dr. La Rue was formerly botanist to a Dutch company in Sumatra.

DR. LUDVIG HEKTOEN, of the John McCormick Institute of Infectious Diseases, has been elected a director of the John Crerar Library in Chicago.

ETHELBERT STEWART, commissioner of labor statistics, United States Department of Labor, has been appointed the representative of that department on the American Engineering Standards Committee, with Lucien W. Chaney, of the Bureau of Labor Statistics, as alternate.

PROFESSOR D. L. VAN DINE, of the Agricultural Extension staff of Pennsylvania State College, has been appointed one of the scientific trustees of the Tropical Plant Research Corporation, a newly formed organization. The objects of this corporation are to promote research for the advancement of knowledge of the plants and crops of the tropics.

IN the College of Engineering and Architecture of the University of Minnesota, Professor J. J. Flather, mechanical engineering, and Professor W. H. Kirchner, drawing and descriptive geometry, have been granted sabbatic leave of absence for the year 1923-24. Professor Flather expects to spend the year at the University of California; Professor Kirchner will travel and study in Europe.

CHESTER K. WENTWORTH, instructor in the department of geology at the University of Iowa, has been appointed to a Bishop Museum fellowship by Yale University for the academic year 1923-24, which will give him the opportunity of a year of field study of volcanic ash and other pyroclastic sediments of the Hawaiian Islands. Mr. Wentworth will leave for Honolulu about September 15.

EUGENE VAN CLEEF, assistant professor of economic and social geography and chairman of the Foreign Trade Division, College of Commerce, Ohio State University, will sail on June 7 for Finland. He will study Finnish life as it may reflect the influences of its physical environment and will compare these observations with similar ones made among the Finns in America.

AT the University of California leave of absence for the purpose of travel and study have been granted as follows: G. N. Lewis, professor of chemistry and dean of the College of Chemistry, will serve as the representative of the United States in the International Union of Pure and Applied Chemistry. He will also deliver addresses before the British Association, the Faraday Society and other scientific meetings to be held in Europe. B. L. Clark, assistant professor of paleontology and director of the museum of paleontology, will complete the mapping of the geology of Mt. Diablo Quadrangle, for the United States Geological Survey. D. R. Hoagland, associate professor of plant nutrition, proposes to spend several months in England at the Universities of Liverpool, London and Cambridge and at the Rothamsted Station. An additional period of several months will be spent in France and Italy, followed by an inspection of experiment stations and other institutions of the United States. A. Smith, assistant professor of soil technology, will conduct studies under the direction of Dean Russell and Professor Whitson at the University of Wisconsin.

DR. C. L. SHEAR, of the Bureau of Plant Industry, United States Department of Agriculture, who was recently placed in charge of the plant disease survey and pathological collections of the bureau, sailed for Europe on May 5. He will represent the United States as one of its delegates to the Pasteur Centennial Celebration to be held in Paris May 26 to June 1 and attend the International Congress of Agriculture at Paris and the International Conference of Phytopathologists in Holland as a delegate for the American Phytopathological Society. He will also make a study of international pathological problems and secure material for the pathological collections of the department.

DR. R. A. MILLIKAN, of the California Institute of Technology, addressed the Physics Club of the Bureau of Standards on April 18, on "The penetrating radiations of the upper air."

PROFESSOR EMERITUS H. L. FAIRCHILD, of the University of Rochester, addressed the students of geology in Lehigh University on Saturday, April 28, describing the development of the drainage systems of New York State.

DR. MICHAEL F. GUYER, of the University of Wisconsin, lectured at Emory University on May 3.

DR. ALBERT KUNTZ, of the St. Louis University School of Medicine, gave a lecture at the State University of Iowa on April 26 under the auspices of the Baconian Club on "The enteric nervous system and the nervous control of gastric and intestinal motility."

SIR ARTHUR KEITH has been elected Vicary lecturer of the Royal College of Surgeons of England for the ensuing year.

AT King's College, London, four lectures commemorating the tercentenary of the birth of Blaise Pascal are to be given by Professor H. Wildon Carr.

THE senate and the board of trustees of the University of Chicago have recommended the establishment of a memorial at the University of Chicago to the late Dean Rollin D. Salisbury, of the Ogden Graduate School of Science, who was also head of the department of geology at the time of his death last August. The committee appointed to decide upon an appropriate memorial includes Mr. T. E. Donnelley, of the board of trustees, as chairman; Professor Harlan H. Barrows, head of the department of geography, vice-chairman, and Professor Edson S. Bastin, who is chairman of the department of geology. Dean Salisbury was connected with the university from its founding in 1892 until his recent death.

DR. SCHUYLER SKAATS WHEELER, president of the Crocker-Wheeler Company of New York and Ampere, N. J., distinguished as an electrical engineer, died in New York City on April 20, aged sixty-three years.

DR. FREDERICK SALATHE, chemist and oil geologist, died at Santa Barbara, Calif., on May 1, aged fifty-seven years.

DR. JAMES MACFARLANE WINFIELD, professor of dermatology in the Long Island Medical College, died on April 24, of injuries received when he was run down by a motor car in Brooklyn. Dr. Winfield was in his sixty-fourth year.

A CORRESPONDENT writes: "Dr. John McLaren McBryde, president emeritus of the Virginia Polytechnic Institute, died in New Orleans, La., March 20, at the residence of his son, Dr. J. M. McBryde, Jr., of Tulane University. Dr. McBryde, who was in his eighty-third year, retired from active service in 1907, when he was granted a retiring allowance by the Carnegie Foundation for the Advancement of Teaching. During his academic career he was a professor at the University of Tennessee, president of the University of South Carolina, president of the Virginia Polytechnic Institute and was the first director of the South Carolina Experiment Station, also director of the Virginia Experiment Station. He was elected the first president of the University of Virginia, first president of Sweet Briar College for Women, president of the University of Tennessee and was offered the post of assistant secretary of agriculture under President Cleveland, but declined all of these offers."

PROFESSOR A. C. BURRILL has resigned as extension entomologist of the University of Missouri to accept a position as curator with the Missouri Resources Museum Commission in the new State Capitol Building, Jefferson City, Missouri. A correspondent writes: "The recent session of the Missouri Legislature has consolidated the work of a formerly delayed attempt to found a historical museum, given over previously to the soldiers and sailors for a flag exhibit and paintings of war scenes with a newly financed scheme for a resource museum devoted to Missouri. The campaign for retrenchment by the last legislature will make this biennium one chiefly of planning exhibits and installing cases for such exhibits as the commissioners wish to start. It is intended that this museum shall sound both the historical and conservational note with regard to Missouri. Since certain groups failed to get either a state pest and plant service, a state forestry commission, a state park system or a state waterways commission in the recent session, it may be logically concluded that the present legislature is now in favor of attempting exhibits along these lines from which the general public will be asked to draw its own conclusions as to what further developments Missouri needs. There are many people outside of Missouri interested in the progress of the state and its resources whose opinions and suggestions will be welcome to the commission."

A SOLAR observatory is to be erected on Mount Stromlo in Canberra territory to link up with institutions in England, India, America and Europe. The British Astronomer Royal and Professor Turner, of Oxford, have been asked to act with Professor Duffield, of University College, Reading, who is now in Australia, in the selection of a director. An opportunity will be given to the director to visit European and American observatories.

THE Florida House of Representatives has passed by a two thirds vote a resolution con-

demning the teaching of evolution in any tax supported institution of the state. It is expected that the same resolution will pass the Senate. The text of the resolution (omitting the preamble) is as follows: "Resolved, that it is the sense of the legislature of the state of Florida that it is improper and subversive to the best interests of the people of the state for any professor, teacher or instructor in the public schools of the state, supported in whole or in part by public taxation, to teach or permit to be taught atheism, agnosticism, Darwinism, or any other hypothesis that links man in blood relation to any form of life."

THE United States Civil Service Commission announces that it will hold an examination on May 23 to obtain candidates for a position on the editorial staff of the United States Geological Survey. The salary offered is $1,800 to $2,400. The examination will include tests in editing technical manuscript, to be weighted 50 per cent.; printing and proofreading, 30 per cent., and correction of errors in footnotes in foreign languages, 5 per cent. In addition a weight of 15 per cent. will be given for scientific education and practical experience. Further particulars concerning the examination can be obtained from the Civil Service Commission or from the editor of the Geological Survey at Washington.

THE Palmolive Company of Milwaukee announces the establishment of a fellowship for the study of the fundamental principles connected with the detergent action of soap. The fellowship carries an annual stipend of $2,000. The fellow will have the privilege of pursuing his studies at any institution in the country which is properly equipped for this purpose. The candidate must possess the equivalent of a master's degree. The fellowship will be awarded by a committee consisting of the following: W. D. Bancroft, professor of chemistry, Cornell University; E. C. Franklin, president American Chemical Society; H. N. Holmes, chairman Colloid Division, National Research Council; Victor Lenher, professor of chemistry, University of Wisconsin, and J. C. Sellner, representing Palmolive Company. Application should be made to Victor Lenher, chairman, Palmolive Fellowship Committee, P. O. Box 281, Milwaukee, Wisconsin.

A RECENT Act of Congress authorizes the Regents of the Smithsonian Institution to prepare preliminary plans for a suitable fireproof building with granite fronts, for the National Gallery of Art, including the National Portrait Gallery and the history collections of the United States National Museum.

WE learn from the *Journal* of the American Medical Association that the Rockefeller mission has completed five years of its active propaganda against tuberculosis in France, and has handed over its services and its activities to the Comité national de défense contre la tuberculose in Paris. The work is in charge of M. Léon Bourgeois and of Professors Calmette and L. Bernard and is carried on in the same way by lectures, motion pictures and other means.

THE will of the late D. Blakeley Hoer, of Brookline, Mass., provides that after the death of various beneficiaries the principal and income from his estate shall be used for acquiring land, preferably on the watershed of the Charles River, for the cultivation of forests thereon forever. The land is to be used for the production of lumber and for bird preserves. Useful birds, especially those feeding on insects injurious to trees, are to be protected always. When the forests become a source of profit, out of the net income 5/15th of the net income is to go to the town of Brookline for its high school; a similar portion to the Brookline public library; 4/15th is to go to Brookline to plant trees and shrubs along or near the streets and 1/15th to Beth Horen Lodge, A. F. and A. M. of Brookline.

THE joint committe recently appointed by the American Society of Mechanical Engineers has decided to accept the offer of the Smithsonian Institution to establish at Washington, D. C., a central historical museum of engineering, in connection with which local branches will be developed in other sections. The museum will be a storehouse for records of American engineering achievements. It will afford opportunities for research and investigation. The plan has obtained the cooperation of the Federated American Engineering Societies, from which body the joint committee was selected by the American Society of Mechanical Engineers. The Smithsonian Institution, in offering to act as custodian of collections, urged that the move-

ment be broadened from an engineering society standpoint to that of a national museum. This idea was acceptable to the engineers and the museum will be founded on the broadest possible basis.

A CONVENTION between the United States and Great Britain for the preservation of the halibut fishery of the north Pacific Ocean, including Bering Sea, was signed March 2 and on March 4 it was ratified by the senate. The chief feature of the convention is a close season on fishing for halibut, both in territorial waters and on the high seas off the western coast of the United States and Canada, from November 16 to February 15 following, both days inclusive. It is provided also that within two months after the exchange of ratifications an International Fisheries Commission, consisting of four members, shall be appointed, two from each country. This commission is to investigate the life history of the Pacific halibut and make recommendations to the two governments as to any regulations that may seem to be desirable for the preservation and development of the halibut fishery. The convention is to continue in force for a period of five years and thereafter until two years from the date when either of the high contracting parties shall give notice to the other of a desire to terminate it.

UNIVERSITY AND EDUCATIONAL NOTES

DR. JAMES A. PATTEN, of Chicago, has given $50,000 to Monmouth College, at Monmouth, Illinois. Mr. Patten's donations to the college now amount to $133,000.

APPLICATION has been made to the Ontario legislature to amend the act of incorporation, changing the name of Western University Medical School, London, to the University of Western Ontario, the desire of the authorities being to make this university the educational center of the western part of the province.

J. A. HILL, wool specialist of the University of Wyoming Agricultural Experiment Station, has been elected dean of the Wyoming College of Agriculture and director of the Wyoming Experiment Station.

DR. CLIFFORD I. CARPENTER, Dr. Arthur W. Thomas and Dr. J. Enrique Zanetti, assistant professors of chemistry in Columbia University, have been promoted to the rank of associate professors.

DR. KIMBALL YOUNG, appointed this year assistant professor at Clark University, will return to the University of Oregon in September to teach social psychology and anthropology.

DR. ROBERT L. PENDLETON, for some years director of the department of agriculture, Gwalior State, India, has been appointed professor of soil technology in the College of Agriculture, Los Banos, Philippine Islands.

DR. J. S. ANDERSON, of the helminthological department of the London School of Tropical Medicine, has been appointed to the chair of medicine at the University of Hong Kong.

DISCUSSION AND CORRESPONDENCE

ERYTHRODEXTRIN IN MAIZE[1]

DR. WEATHERWAX has found that the endosperm of Chinese waxy maize when tested with a solution of iodine dissolved in aqueous potassium iodide gives a red color reaction instead of the characteristic violet color of starch. From this phenomenon he infers that the endosperm of waxy maize is composed not of starch but wholly of a relatively rare substance, erythrodextrin. In a criticism of Weatherwax's paper East[2] questions the propriety of designating this substance erythrodextrin based solely on its color reaction and possibly there is justification for his position. This difference of opinion, however, must not be allowed to obscure the fact that the endosperm of waxy maize can be differentiated from the endosperms of all other known types by its color reaction when treated with iodine solution and whether Weatherwax's contention is substantiated or not will not materially affect the value of his discovery which remains as a distinct contribution to the genetics of maize.

The iodine test has made possible the identification of the double recessive combination of waxy and sweet obtained in the F_2 of hybrids between the waxy type and varieties of sweet

[1] Weatherwax, Paul. A rare carbohydrate in waxy maize. *Genetics*, 7, 568-572, 1923.

[2] East, E. M. Weatherwax on maize endosperm. SCIENCE, LVII, No. 1475, pp. 416-418, April 6, 1923.

corn. This double recessive combination completely resembled sweet seeds in contour and could only be determined by subsequent breeding tests. The iodine method has been of value also in separating the waxy from the starchy seeds in hybrids with the large-seeded Cuzco variety where heretofore classification has been impossible owing to the looseness of the carbohydrate particles.

The fact must not be overlooked, however, that the identification of the carbohydrate as erythrodextrin does not furnish a complete explanation of the physical properties of waxy endosperm since like starch this carbohydrate can be found in an extremely floury condition.

The chief criticism of this latest contribution of Weatherwax to the literature of maize and it applies equally well to several of his previous papers has been epitomized aptly by East in his phrase "blending of the didactic and the dogmatic" but this manner of presentation of course is purely personal and should not detract from the observed facts.

A more serious defect and one also not unique in this paper on erythrodextrin is a tendency to magnify the importance of minor discoveries.

This tendency is well illustrated by the extended discussion of the genetic difficulties met with in sweet-starchy maize hybrids—difficulties which hardly can be solved by the discovery that waxy endosperm turns red in a solution of iodine—and the discussion of this subject might well have been postponed until a true chemical solution could be offered.

Appreciating that there was to be a delay in publication Dr. Weatherwax kindly furnished us with a copy of his manuscript early last May and at that time his statement that "the sporadic appearance of sweet corn as a mutant from starchy corn in many parts of America is known" was questioned. Since he has not found it expedient to qualify this statement it seems desirable to record that as far as we are aware no such mutations are known to geneticists. In the thousands of guarded pollinations that have been been made in starchy maize varieties in the past decade not a single instance of a mutation to sweet seeds has been reported. While the value of the discovery of the red reaction of waxy endosperm in iodine solution can not be affected by the truth or falsity of this observation, it seems unfortunate that such a statement should be published under circumstances likely to afford it credence.

J. H. KEMPTON

BUREAU OF PLANT INDUSTRY

THE PERSONAL EQUATION AND REACTION TIMES

THE question whether personal equation in star transits is a matter of reaction time may be one that has been somewhat confused by not using the respective terms with the same significance.

But perhaps the real difficulty has been in the interpretation of the particular form of personal equation in this case. The usual understanding of recorded chronograph transits is based on the explanation given in books on descriptive astronomy, in which the observer is represented as tapping the key in coincidence with the instant when a star is on the wire, as nearly as he can do so. The flying bird and a sportsman, armed with a gun, is the popular illustration. Thus for a Mallard, dropping into decoys, we allow a lead of a yard, while for the Black Brant, commonly called a goose in California, we lead ten feet, because he is flying high and his size makes his real speed very deceptive.

My own habit of observing, however, based upon early consultation with such masters in the "old astronomy" as Benjamin Gould and Lewis Boss, has been to tap the key when I see the star on the wire. Thus every record is late and consciously late, but the advantage is that accidental deviations from uniformity of record are presumed to be smaller than they would be in efforts to allow for the motion of the stars as they approach the wire, each with a special velocity.

The systematic error thus introduced is a part of the personal equation and would be of importance in the determination of absolute clock corrections and in longitude work. It is eliminated in the measures of right ascensions where the observed clock correction and clock rate depend upon observations of standard stars. We are there concerned in making the accumulated accidental errors of observation as small as possible.

My own understanding of the reaction time in this process is the elapsed interval between

the instant when the eye perceives the star to be on the wire, and the record of that perception by the finger with the key. Any estimate of coincidence based on judgment of speed or time interval does not enter. This estimate would appear to be the "synchronization of reactions and anticipated stimuli." Or, is an agreement to be prevented by the obstacle of a mutual understanding of familiar phenomena with a misunderstanding of the words in which they are described. In this freely translated "classical definition" of psychological descriptions I certainly do not wish to be understood as concurring.

Without pretense of undue modesty in the matter the conclusion established in my note in SCIENCE was not presumed to be a novel one in the domain of psychology. But the form of the test appears to be new, the comparison of the hourly rate of a clock at night with the daily rate at the epoch; and then only new as regards its completeness and the elimination of systematic errors as fully as possible. The tabulated results are not an exposition of the personal equation nor of reactions. They give the mean deviations of my personal equation from uniformity, and while fatigue is acknowledged to be existent it has introduced no mean deviation as large as the one-hundredth of a second in the intervals of two hours each. If these results, in their completeness and precision, contribute to the establishment of facts that are of interest to psychologists, that seems to be a matter of our mutual benefit.

R. H. TUCKER

LICK OBSERVATORY,
UNIVERSITY OF CALIFORNIA

We find in the psychological laboratory that there are two quite distinguishable conditions for reaction to a visual stimulus. Under one condition, which we have conventionally described as "simple reaction," the stimulus appears suddenly, at a moment which the reactor cannot predict, although he is given a "warning signal" preceding the stimulus by the period of from 1¼ to 1¾ seconds, understanding fully that the foreperiod is thus variable. The reactor's attention is thus approximately at its best during the short period of time within which the stimulus may actually appear. Under such conditions the average value of the reaction time should be from 130 to 160 *sigma*, varying in accordance with factors such as the type of individual, the amount of previous practice, etc. The average may, under certain conditions, have a value somewhat greater, but if over 180 *sigma*, we at once suspect serious error in the technique of obtaining and measuring the reactions, and even under the best conditions, with experienced reactors, an average of less than 120 *sigma* is unusual. The distribution of the individual reactions is, however, wide and a mean variation of not over 10 per cent. of the average is considered a safe measure of reliability. On this account, from 100 to 500 reactions are required to establish a valid average for a given reactor under given conditions.

The second condition for reaction (which is found in the so-called "complication experiment") is that in which the reactor sees the stimulus-pattern changing at a uniform rate towards an expected stage at which it constitutes the "stimulus." For example, he sees the star approaching the cross-wire in a transit instrument, or a pointer approaching a given mark on a dial; and the coincidence of star and cross-wire, or pointer and mark, constitutes the "stimulus." Under this condition, two different types of reaction are obtained: (*a*) When the reactor attempts to make his reaction *synchronous* with the stimulus pattern. In this case the reaction may actually follow or may precede the stimulus-pattern when seeming synchronous, but the positive or negative error usually varies from a few *sigma* to 30 *sigma*. (*b*) When the reactor may definitely attempt to make his reaction *follow* the stimulus pattern. Even in this case, although the reactor may succeed in making his "error" positive, it is usually relatively small; that is to say, only a fraction of the normal "simple reaction" time. In other words, the conditions here are those described under the first type (*a*) but with a subjective "set," which makes the error positive. This, however, is only one type of condition which will give a positive rather than a negative error in reactions of the "complication" type. It is not necessary that the estimation of the course of change in the stimulus-pattern should be consciously made. In fact, the actual stimulus-

pattern for any reaction under such circumstances involves a temporal factor whether the reactor analyzes the temporal factor or not.

Whether a certain group of reactions to a visual stimulus are of the "simple reaction" or the "complication" type can usually be decided from the average value, even where the conditions of reaction are not fully described. If the average is over 120 *sigma*, the reactions were mostly of the "simple reaction" type, although (if we do not know all the conditions) we can not be assured that some reactions of the other type may not have been mixed in. If, however, the average is under 50 *sigma*, we can be certain that the reactions were practically all of the "complication" type, since the "simple reaction" will seldom occur if conditions are such that the "complication" reaction can occur, and is occurring in the majority of cases.

With these facts in view, it seems to me that there is no room for confusion between the conceptions of the psychologist and those of the astronomers.

KNIGHT DUNLAP

THE JOHNS HOPKINS UNIVERSITY

ÆROBIC?

DR. W. W. KEEN'S objection to the word "erobic" (SCIENCE, March 23, p. 360) is perfectly valid. However, the substitute he proposes is equally objectionable. The Greek word is ἀηρ. Like most of our Greek words this comes to us through the Latin transcription, in this case aër, formerly written with a dieresis. Now that the dieresis is no longer in vogue, some confusion is apt to occur. At any rate, the word is a dissyllable and not a diphthong. Dr. Keen would not propose the use of a diphthong in the words aerate, aerial, aeronaut, etc.

ARTHUR W. DOX

DETROIT, MICHIGAN

TO THE EDITOR OF SCIENCE—Dr. Dox surely has misread my letter in SCIENCE protesting against "erobic." I urged the retention of the "aer" as a disyllable. Personally I should use the diacritical mark to indicate the proper pronunciation.

The dropping of all accents in French by the newspapers during the war is wrecking their pronunciation, *e.g.*, "Poincaré" is often pronounced "Poin-car" or "Poin-care" and "communiqué" is distorted into "communeek" or even "communeek-quee."

If Dr. Dox will consult the Oxford Dictionary he will find that "disyllable" with one "s" is preferable to double s and that "dipthong" is an obsolete form of "diphthong" which in Greek is spelled with φ and θ (ph and th).

W. W. KEEN.

QUOTATIONS

PARK CONSERVATION

No one can justly charge the American Association for the Advancement of Science with flightiness, or suspect it of being swept off its feet through unpractical sentimentalism. Its strong plea to the governments and people of the United States and Canada that the great wild parks of both countries be more completely safeguarded against commercial exploitation of every form will, therefore, command attention and respect. The resolutions that the association has now issued upon this subject would seem to indicate that it recognizes the threatened encroachment of power developments within the national parks of both countries. Its appeal is not addressed to this particular menace alone, however, but calls attention to the fact that the parks are in many cases open to incursion by those who regard their various natural resources with covetous eyes. Gradually the public is coming to understand that the national parks are by no means as proof against materialistic raids as had been supposed. This call for a greater degree of protection, coming as it does from one of the most distinguished scientific organizations in the world, will tend to emphasize the situation and carry conviction as to its economic importance.

It will not be suspected that this association is unsympathetic with the endeavors of those who are legitimately developing the resources of the two countries. There is more than an implication in its resolutions, though, that it would be poor business to allow the material resources of the parks to be utilized except in those cases where a compelling and unquestionable public necessity exists. To safeguard the parks more thoroughly against unnecessary utilitarian developments, the association recom-

mends that the governments of the United States and Canada amend existing laws and secure such new enactments as may be needed to afford complete conservation to all units of what it terms "a unique continental exposition of inestimable value to science and to the popular education of future generations." —*Boston Evening Transcript.*

SCIENTIFIC BOOKS

Exercise in Education and Medicine. By R. TAIT MCKENZIE, M. D., director of physical education, University of Pennsylvania. The W. B. Saunders Company, Philadelphia, 1923.

Here is a book published by the W. B. Saunders Company of Philadelphia that quite delights us. The author has the courage of his convictions and has dared to put forward as the main title of his book that good virile word exercise—from the Latin exercitium, which originally meant "to drive out," "drive on," "set at work." The derived meanings of this word are full of significance at the present time: "to set in action," "to give employment to," "to school or train"; and consequently "to exert for training or improvement" and "to improve by practice" or "to perform for training."

At an age when the would-be leaders of men and creators of public opinion are playing to the intelligence of the lowest mentality for the sake of reaching the largest numbers, is it not time to call a halt to the descent to moral mushiness and spineless effort and make an appeal for higher standards of mental and physical activity? It does us no good to ascribe our soft, safe and superficial way of doing things to the relaxation that always follows a war. Rather should we profit by the lessons learned in the conflict. The recent war taught us two most valuable lessons—the feebleness and incapacity of over one half of the drafted men for service who had spent little time in exercising for self improvement, and the hardihood and efficiency of the men who were trained by vigorous pursuits for the army. Here again we meet our effective exercitium, the vigorous physical efforts which were first used to train and develop the Roman army which made the term applicable. Again it was *exercitium* that laid the foundation for the training and discipline of the German army. One conquered the world under Caesar, the other held the world at bay for three years under a Prussian Kaiser.

Waiving for the time being the great Christian, moral, ethical or political issues at stake, this fundamental biological principle can not be set aside; we can not get strength, either as individuals or as a nation, without making strong and vigorous efforts. The ability to drive on and guide and direct our efforts toward our own improvement is a God-given faculty that man can not afford to despise. It is only by perfecting our own mechanism that we can hope to maintain a footing in the world and be of any service to others. Here is the philosophy of physical education in a nut shell. The individual gradually acquires those qualities which his special activities require him to put forth. Thus if the activity requires strength, strength will follow with each effort. If it requires skill, skill will come with practice. If it requires alertness, poise, courage, self-command, all these qualities will be further developed as a matter of course.

With these simple fundamental truths in mind, it is interesting to see how Dr. McKenzie has followed the evolution of the general subject of physical education in the United States. Tracing as a physician the physiological effect on the individual of light, heavy and strenuous exercise upon the muscles, heart, lungs and nervous system, he proceeds to analyze the effects of different exercises upon age, sex and occupations.

All exercises are modified in their effects by environments and the supplementary agents of health, air, diet, sleep and clothing—which must be properly regulated and adjusted in order to bring the best results.

He has reviewed the German and the Swedish systems of gymnastics and traced their influence through our American schools and colleges. The influence of English sports and games and the modifying effects of athletics upon our foreign systems of gymnastics develop as we progress through the different chapters. The growth and spread of the general movement for physical improvement of the masses show themselves in the physical program adopted by the Christian Associations,

the Boy and Girl Scouts, the Camp Fire Girls and by many other social organizations. Such movements as the growing interest in public baths, the establishment of city playgrounds and the universality of summer camps all testify to the public consciousness of the importance of physical exercise.

Dr. McKenzie has done much to popularize this great movement through the publication of previous editions of this book. The greatest service, however, which he has rendered to the cause of education and to the general public is in calling attention to what physical exercise properly directed will do for the blind, deaf mutes and mental and moral defectives. The interest in physical education has opened a new world to these unfortunate members of the community.

The advent of the great war brought into prominence the value of physical methods in the practice of medicine. No one in the country was better posted than Dr. McKenzie in this branch of therapeutic service, after his extensive study in private and institutional practice. Because of this interest, Dr. McKenzie devoted the last part of his previous book to "Exercise in medicine." It is all the more fitting that the author should devote more attention to this branch of the work in this edition when his previous experience has been supplemented by two years' service as physical training and medical officer in the army during the war and as inspector of physical therapy in convalescent camps and hospitals throughout England, Canada and the United States.

The chapters in this part of the book naturally take up the application of exercise to diseased conditions. Since all parts of the body, including the back, chest, arms, legs, hands and feet function through the use of the muscles and nearly all of the important organs of the body, such as the heart, lungs, stomach, glands, blood vessels and viscera, are dependent upon the contraction of muscles for the proper performance of their functions, the health and tone of the muscular system is a matter of the greatest importance. Not only this set of organs, but even the functions of the brain and nervous system which regulate the rest of the body are dependent upon the condition of the master tissues of the body, the muscles. "This was (to most physicians) for some time a paradox, but now time and experience seem proving it true."

It seems only a natural step from education and developmental gymnastics to medical gymnastics as Hippocrates and Herodotus advocated it.

Dr. McKenzie has shown in this book on exercise how the modified and judicious use of the muscles may be made to restore all parts dependent upon muscular activity to their normal functions. Armed with this knowledge, the physician or his attendant may undertake the treatment of flat feet, weak joints, round backs, drooping heads, uneven shoulders, curved spines, flat chests, abdominal weaknesses and many other bodily weaknesses and imperfections with reasonable hope of complete recovery. Even many diseases of the heart, lungs, stomach and brain may be safely treated through the effect of moderated exercise on the circulatory, respiratory, digestive and central nervous systems.

The author's experience with wounded and diseased men in the war has enabled him to bring the physical treatment right up to date. His ingenuity in devising mechanical appliances to assist the patient in helping himself, and, through his knowledge of applied anatomy, his understanding of the action of the muscles and joints through practice in gymnastics has contributed to make this part of the book unsurpassed as a guide to physicians in physiotherapy.

Perhaps the crowning feature of the book is the apt use of illustrations in both the educational and the medical sections. Here again the author, being a sculptor as well as a physical educator and a physician, has used his artistic eye in selecting the appropriate photographs and the best kinds of models, displaying the proper poses to show the particular action to which he desires to call attention. In fact the work is so meritorious that all people, whether they be physical educators, practicing physicians or intelligent laymen, have reason to thank Dr. McKenzie for taking the time from his absorbing profession to prepare such a book for their benefit. Suffice it to say that every one interested in the general subject should own a copy.

DUDLEY A. SARGENT

FEBRUARY 21, 1923

SPECIAL ARTICLES

NOTE ON THE EQUATIONS FOR TORTUOSITY IN THOMSON AND TAIT'S NATURAL PHILOSOPHY

THE occurrence of two very different expressions for the same thing is always puzzling. It may not, therefore, be superfluous to consider them.

1. If α, β, γ, λ, μ, ν are the direction cosines of the radius of curvature R, and of the corresponding normal N to the osculating plane, respectively, the first expression in the well-known classic (section 9, edition 1879), is $t^2 = \lambda'^2 + \mu'^2 + \gamma'^2$, where the dashes denote d/ds and s is the independent variable. This is equivalent to the vector tortuosity, $T = d\,(RN)/ds = i\lambda' + j\,\mu' + k\,\nu'$, and is the obvious increment of the unit normal, RN, per cm. along s, *in full*, and in the direction $RN' + R'N$. But as both N and N' are vector products each containing r', this T has no projection on the tangent; and, therefore, for counter-clockwise rotation seen in the direction of the tangent, points in the direction of the radius of curvature.

2. The second expression reads:

$$t^2 = \left(\mu \frac{d\nu}{ds} - \nu \frac{d\mu}{ds} \right) + \text{etc.}$$

and is thus vectorially equivalent to
$T' = R\,N \times d\,(R\,N)\,/\,ds = R^2\,N \times N' + 0$;
and if we insert the vector equations for N and N'

$$-T' = R^2\,(r' \times r'') \times (r' \times r''')$$
$$= r'\,R^2\,(r' \times r''')\,.\,r''$$
$$= r'\,R^2\,(i\,\lambda' + j\,\mu' + k\,\nu')\,/\,R - NR'/R)\,.\,r''$$
$$= r'\,T\,.\,R_1 = r'\,(\alpha\,\lambda' + \beta\,\mu' + \gamma\,\nu'),$$

the subscript denoting a unit vector. Thus, in value, T' is again the projection of T on the radius of curvature R. The former (T') is laid off, however, along the tangent, since T and R are opposed in direction, and is thus a very different thing from T, which is not an immediate tortuosity. The case is analogous to the occurrence of two expressions for the radius of curvature: $(r'')^{-1}$ in the osculating plane and pointing towards the center; and $(r' \times r'')^{-1}$, laid off along the corresponding normal to that plane, inward.

If the normal N had been defined (preferably here, I think) as $r'' \times r'$, rather than as above, the clockwise rotation of the osculating plane seen in the direction of the tangent would correspond to a vector T in the direction of radius of curvature. T' would at once be positive in the direction of the tangent r', without compromise; but opposition of sign is none the less inherent in the two projected tortuosities or angles, $d\,R_1/ds\,.\,N_1$ and $d\,N_1/ds\,.\,R_1$.

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VERY SOFT X-RAYS—THE M — SERIES FOR IRON

DURING the past two years several investigators have reported attempts to study the portion of the spectrum lying between the Millikan region and the X-ray region by means of the photoelectric action of the radiation. In every case the curves obtained by plotting the photoelectric current against the accelerating voltage applied to the electrons which generated the radiation showed one or two discontinuities which were interpreted as indicating the excitation of one of the X-ray series in the region under investigation. Now in the ordinary X-ray region the characteristic absorption limits have been found to possess a fine structure which has been interpreted by Kossel as corresponding to the ejection of an electron from one of the inner shells of the atom to the various optical orbits in the outer portion of the atom. If such an explanation is correct then a similar phenomenon should be observed in the soft X-ray region, and therefore we should expect to find not one break in the photoelectric current but several for each X-ray absorption limit. This has been observed by the writer in his research on the soft X-rays, and as the work is still in progress it seems advisable to make a preliminary report at this time.

The apparatus used is in principle the same as that employed by Hughes. The radiation was excited by bombarding a solid target with electrons from a hot tungsten cathode. The radiation fell on a platinum plate producing a photoelectric current which was measured by means of a Compton electrometer using the constant deflection method. Positive ions and electrons were kept from reaching the photoelectric plate by two gauzes, one of which was

kept 15-20 volts negative to the negative end of the filament and the other at least 75 volts positive to the anticathode. A third gauze acted as a receiver for the photoelectrons. These gauzes were constructed on metal cylinders so arranged that the only surfaces exposed to the radiation were of metal and at known potentials. The parts of the tube around the photoelectric plate were shielded from the direct action of the radiation. Before making any measurements the tube was baked and evacuated until the pressure under conditions prevailing during experimentation was so low that it would not register on a McLeod gauge which could measure a pressure of 10^{-5} mm. It was found to be impossible to obtain reproducible results at higher pressures.

The curves obtained by plotting the total photoelectric current against the voltage applied to the exciting electrons are similar in appearance to those obtained by Franck and Einsporn for mercury using low voltages. Up to the present time nine distinct breaks have been obtained for iron in the region from 40 to 185 volts. The values for these points are:

Voltage	ν/R	λ
46.8	3.46	264 A
81.7	6.03	151
95.4	7.05	129.6
111.2	8.21	111.0
130.4	9.63	94.6
140.9	10.40	87.8
171.1	10.88	83.9
153.7	11.33	80.5
160.1	11.83	77.0

The wave length, λ, is in Angstrom units, ν is the frequency and R the Rydberg constant.

The first of these points corresponds very well with the value calculated from X-ray data for the transition from the N_5—N_6 level to the M_3—M_4 (the separation between M_3 and M_4 or N_5 and N_6 is too small to be considered in these experiments). This difference can be obtained from the ν/R values for the Kβ and Kγ lines as given by Siegbahn. The values are 519.55 and 523.1 respectively, giving 3.55 as the difference which is in good agreement with the value of 3.46 as obtained by the writer. The results have also been successfully checked by using the combination principle to calculate lines in the Millikan region. A more detailed account of this work with additional results will be published in the near future.

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(Continued)

Solubility relations among aluminum and antimony salts: E. D. CRITTENDEN. Freezing point curves for pairs of (*a*) aluminum salts and (*b*) antimony salts have been determined by the closed tube method previously employed. With the exception of two compounds in the system, $SbCl_3$-$SbBr_3$, compound formation is entirely lacking in the temperature range investigated. Solubility is limited in several cases and in this regard the almost complete insolubility of AlF_3 in the other aluminum halides may be cited. In the antimony series solubility is more extensive. Several cases of partial miscibility in the solid state have been found. The results indicate that the rules already established by Kendall for binary systems in which the negative radical is constant and the positive varied as widely as possible, apply to the reverse case studied here. By comparing the results in the two series, the marked effect of unsaturation in increasing solubility is clearly indicated.

A reciprocal catalytic pair: A. W. BROWNE. In catalytic actions where the agent is of the "carrier" type, it should be possible to use interchangeably the filled and the empty carrier, particularly if these are distinct chemical compounds that may be isolated, and if therefore the filling of the carrier is a chemical process. These two forms of the carrier constitute what may be termed a *reciprocal catalytic pair*, that is, a pair of chemical compounds which undergo repeated mutual conversion into each other while exerting their catalytic effect upon a given chemical reaction. Potassium azido-dithiocarbonate, $KSCSN_3$, and azido-carbondisulphide $(SCSN_3)_2$, two new compounds that have been isolated and studied at Cornell, have been found to exert an identical catalytic effect upon the reaction between potassium trinitride andiiodine, which may be expressed by the equations:

(1) $2\ KSCSN_3 + I_2 = 2KI - (SCSN_3)_2$

(2) $2\ KN_3 - (SCSN_3)_2 = -2KSCSN_3\ 2N_3$

(3) $2N_3 = 3N_2$

Physical-chemical studies of creatine and creatinine (I) creatine hydrolysis in acid solution: GRAHAM EDGAR AND R. A. WAKEFIELD. An ex-

perimental study has been made of the rate of conversion of creatine to creatinine in the pressure of hydrochloric acid of various concentrations, and at temperatures between 25°C. and 100°C. The reaction proves to be monomolecular the reaction velocity constants increasing a little more rapidly the acid concentration. The variation of the constants with temperature is expressed exactly by the Arrhenius equation, the "critical increment" being 20,000 cal., a value of the order of that found by Lewis for the hydrolysis of methyl acetate and cane sugar in the presence of hydrochloric acid.

The degrees of hydrolysis of the sodium salts of some organic developing agents: FELIX A. ELLIOTT. The degrees of hydrolysis have been determined electrometrically at varying concentrations and temperatures of mono- and di-sodium hydroquinonate, mono-, di- and tri-sodium pyrogallate, mono-sodium p-amino phenol and mono-sodium mono methyl p-amino phenol. The order of magnitude suggests that these agents are classifiable with the pseudo-acids of Hantsch.

The diffusion of helium through quartz at room temperature: HOWARD M. ELSEY. Helium confined under one hundred atmospheres pressure at room temperature will diffuse through a thin walled quartz tube rapidly enough to be detected spectroscopically after a few hours.

Physical chemistry of some volcanic phenomena: GEORGE W. MOREY. A characteristic of volcanoes is the building up of pressure of volatile components as the magma cools. This is as would be expected of a system containing both volatile and non-volatile components, when the latter crystallize on cooling; and the development of pressure in a crystallizing magma is competent to explain many phases of volcanism. The intermittent action of many volcanoes of the explosive type is explicable on the basis of the rate of release of volatile materials at different levels, together with the heat available from the Joule-Thomson effect at high temperatures.

Plasticity and elasticity: EUGENE C. BINGHAM. Elasticity is usually so defined as to exclude all liquids, no matter how viscous they may be. But many viscous liquids, such as glass, for example, undergo elastic deformation exactly as do true solids below their elastic limit. The term elasticity should be so extended as to include fluids as well as solids or else we must invent a new term. Elastic deformations are not a function of the time as are viscous or plastic deformations, hence it is easy to distinguish between them. In liquids and in solids above their elastic limits the flow tends to obliterate the strain and therefore elastic deformations tend to disappear, but this does not make the elasticity of these bodies any the less real even though it is more difficult to observe and measure. The elastic after-effect is discussed as an example of plastic flow.

Limiting factors determining the concentration of electrolytic potassium amalgam: CLARE MARTIN AND JAMES R. WITHROW. The authors call attention to, and endeavor to explain the failure of previous workers to obtain concentrated potassium amalgams electrolytically. In a series of experiments with the Shepherd method, they successively eliminate as vital factors (1) exhaustion of the electrolyte, (2) plugging up of the pores of the porous cup, (3) an equilibrium between the rate of formation and decomposition of the amalgam. From a consideration of Kurnakow's curve, they suggest that too low temperature has been the chief limiting factor. Electrolyzing at higher temperatures, they obtain potassium amalgams analyzing 4.69 per cent. potassium. No higher than 2.23 per cent. K. had been previously obtained and Kerp and Bottger state that exceeding 1.6 was accomplished with the greatest difficulty.

The limiting density of phosgene: A. F. O. GERMANN AND LELAND R. SMITH. The volumetric method used by Morley in his classic researches on the densities of oxygen and hydrogen has been employed in a series of determinations of the density of phosgene. The results parallel those of Germann and Jersey, in that the density of successive fractions of phosgene rises to an approximately constant value, which is, however, below the probable density of the gas. Density measurements were made at pressures of 500 mm., 335 mm. and 170 mm., using a five liter globe. While the absolute numerical value of the results is of little moment, still it is important to note that the limiting density found is approximately four per cent. less than the density at 500 mm., that is, the deviation from Boyle's law amounts to about six per cent. per atmosphere at zero. Our knowledge of the properties of vapors near the point of condensation is very incomplete. Probably no perfectly pure specimen of phosgene has as yet been obtained. The usual methods for the preparation of phosgene yield a product difficult to purify because the impurities are for the most part very soluble in the liquefied gas. It is most important for the progress of the study of the properties of phosgene that a method be developed for the rapid and complete purification of the technical product. Work in this direction in cooperation with the chemical warfare service is in progress at the Stanford Laboratory.

Production of metallic beryllium and its al-

loys: B. S. HOPKINS AND E. A. ENGLE. BeO was found to be readily soluble in fused cryolite, but the electrolysis of the solution gave aluminium containing little beryllium. Electrolysis of fused sodium beryllium fluoride yielded considerable metallic beryllium, but it flaked off and was mixed with the oxide, carbide and fluoride. These were separated and flaky beryllium 98 per cent. pure was obtained. Similar electrolyses with metallic cathodes gave alloys containing some beryllium. The chief difficulties in preparing these alloys arise (1) from the tendency of the beryllium to oxidize and (2) from the change in density produced by the introduction of beryllium. Some beryllium-aluminium alloy was produced by preventing the fused metal from rising to the surface.

Preparation and properties of some rare earth metals: H. C. KREMERS. With few exceptions the rare earth metals are more electropositive than aluminum, but less so than the alkaline earth metals. Reduction of the anhydrous chlorides with sodium gives only impure metal. Electrolysis of flourides or double flourides results in excessive passivity of the anode due to deposition of fluorine. Those rare earths which are more basic than aluminum can not be electrolized by dissolving the oxide in fused cryolite. Electrolysis of the anhydrous chlorides is most satisfactory. Lanthanum and neodymium have been prepared in quantity and many of their properties studied. Lanthanum being most basic tarnishes very rapidly. Neodymium oxidizes only after several hours exposure to air. Neither lanthanum or neodymium show pyrophoric properties in the ordinary way. Sparks are emitted only when the metals are violently struck. Yttrium metal is being prepared by electrolysis of the fused chlorides. Some of its properties are given.

A tantalide of aluminum: W. H. CHAPIN. The tantalide was first prepared by using a modification of the Goldschmit process directly on powdered tantalite. It was found by analysis to correspond to the formula Al_3Ta. Other methods of preparing the compound have been developed. The properties of this tantalide are proving very interesting and important: It is not acted upon by any single acid except H_2F_2; does not oxidize below white heat; reacts with HCl gas at 600°C. We give $AlCl_3 \pm TaCl_5$, releasing the equivalent amount of H_2. Other properties are being studied.

A new halogenoid and halogenoid hydracid: A. B. HOEL, G. B. L. SMITH AND A. W. BROWNE. Azido-carbondisulphide $(SCSN_3)_2$, prepared by oxidation of sodium or potassium azido-dithiocarbonate in aqueous solution, is a white, crystalline, explosive solid, very slightly soluble in water, but soluble in various organic liquids, particularly acetone. It undergoes autocatalysis even at ordinary temperatures, yielding a mixture of polymeric thiocyanogen and free sulphur as the final product. It dissolves readily in KOH, yielding at low temperatures potassium azido-dithiocarbonate and potassium oxy-azido-dithiocarbonate, analogous to the chloride and hypochlorite formed when free chlorine dissolves in KOH. From the solution obtained, sulphuric acid reprecipitates the "free" azido-carbon-disulphide. Azido-dithiocarbonic acid, $HSCSN_3$, is obtained by treatment of a concentrated solution of sodium or potassium azido-dithiocarbonate with conc. HCl in the cold. It is a white, crystalline solid, soluble in water and in many organic solvents, and is almost as strong an acid as HCl. It decomposes autocatalytically at ordinary temperatures.

A study of adsorption of gases on a surface of mercury: H. H. KING AND J. LOWE HALL. Preliminary paper: A new method of measuring the angle of contact between mercury and glass, and the determination of surface tension of mercury. The purpose of this investigation is to study the adsorption of various gases under pressure variation on a surface of mercury through the corresponding changes in surface tension. A new method of measuring the angle of contact and determining the surface tension has been worked out wherein the mercury surface has maximum opportunity to remain undisturbed in equilibrium with the gas at the desired pressure throughout the determination.

Demonstration of a projection electroscope and a projection volt-ammeter: HOWARD M. ELSEY. These instruments have been designed to take the place of the slide carrier in a projection lantern. The ease with which experiments in radioactivity and electro-chemistry can be shown to large audiences by the use of these instruments will be demonstrated.

Capillary rise measurements in tubes of various metals a new method of surface tension measurement: E. K. CARVER. It was found by Bigelow and Hunter (*Jour. Phys. Chem.*, xv, 367, 1911) that water and benzene rose to different heights in tubes of various metals, and that the height became greater the more electropositive the metal. To verify this an apparatus somewhat similar to theirs was used. A plate of the metal, 1 cm. in diameter, was ground flat and a capillary hole was drilled through it. The diameter of the hole was measured with a micrometer microscope. A glass tube, 1 cm. in diameter, the end of which